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May 20, 1998

Assistant Commissioner For Patents
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Dear Sir:

United States Patent Application For:
Inventors: James Haworth, Friedhelm Brinkhaus, and John Greaves
Our File No. 4532670/19300
Title: METHOD OF EXTRACTING ANTIOXIDANTS FROM LAMIACEAE SPECIES AND THE EXTRACT PRODUCTS THEREOF

Enclosed please find the above-identified patent application together with the necessary documents for filing with the United States Patent and Trademark Office:

[X] Specification with attached Declaration
[ ] Specification without attached Declaration

[ ] Formal Drawings
[X] Informal Drawings

[ ] Prior Art Statement under 37 C.F.R. §1.97

[ ] Preliminary Amendment

[ ] An Assignment of the invention in favor of the following organization is enclosed for recordation:

Any notice that is to be furnished to the above organization after grant of the patent should be addressed to the firm of undersigned; any notice for

any other reason should be addressed to the organization with the notation, "Attention: Office of the President."

Payment enclosed herewith includes an $40 assignment recordation fee.

[ ] Priority is hereby claimed based upon the following applications, a copy of each being attached hereto:

[X] The total amount due for the filing fee in this case is:

Basic Filing Fee $790 ($395 small entity)	$395.00
Independent Claims above 3, $82 each ($41)	_____
Total Claims in Excess of 20, $22 each ($11)	_____
Multiple Dependence Penalty, $250 ($125)	_____
Assignment $40	_____

TOTAL DUE..... $395.00

[X] Where a 50% fee reduction is indicated in the calculation in the preceding paragraph, documentation making this claim under 37 C.F.R. §1.9(f) is attached.
Verified Statement of Independent Inventors and
Verified Statement of Small Business Concern

[X] Our payment is included in the amount of the TOTAL DUE in the following manner:

[X] Our check in the full amount is included.

[X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Account No. 12-2250. A duplicate copy of this sheet is enclosed.

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Respectfully submitted,

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May 20, 1998

By _____
Margaret L. Edwards

METHOD OF EXTRACTING ANTIOXIDANTS FROM LABIATE SPECIES AND THE EXTRACT PRODUCTS THEREOF

Background of the Invention

1. Field of the Invention

The invention relates generally to a method for extracting antioxidants from and, more specifically, to an improved method of extracting antioxidants from species of the family Labiatae, in particular, rosemary (*Rosemarinus officinalis*), using tetrafluoroethane based solvent blends and which yields a liquid and oily extract that is readily mixed with an edible oil for addition to animal feeds and human food.

2. Background of the Prior Art

Worldwide demand for natural antioxidants has been rising due to safety concerns about synthetic food and feed additives and the public perception that natural food and feed supplements provide certain health benefits. The most important natural antioxidants being exploited commercially today are tocopherols. Tocopherols have a potent ability to inhibit lipid peroxidation *in vivo* by trapping peroxy radicals (Burton, G. W., and K. U Ingold (1989), in Vitamin E: Biochemistry and Health Implications, edited by A. T. Diplock, L. J. Machlin, L. Packer and W. A. Pryor, The New York Academy of Sciences, New York, pp 7-22). Various herbal extracts for use as natural antioxidants are being explored. Possibilities include the extraction of rosemary or other botanical sources. Such new antioxidants may play a role in combating carcinogenesis as well as the aging process, and may be applicable in the nutraceutical industry.

Among the various natural extracts available in the market are rosemary extracts, which are reported to be highly effective in retarding lipid oxidation and protecting living cells from the damaging oxidative stress (Chen, Q., H. Shi and C-T Ho (1992), "Effects of rosemary extracts and major constituents on lipid oxidation and soybean lipoxygenase activity", J Am Oil Chem Soc 69: 999-1002; Wong, J. W., K. Hashimoto and T. Shibamoto (1995), "Antioxidant activities of rosemary and sage extracts and vitamin E in a model meat system", J Agric Food Chem 43: 2707-2712). These extracts are described as being superior to vitamin E, a well-known natural antioxidant and food supplement, in many food model systems (Lolinge, J, (1983), Natural antioxidants *in* Allen, J. C. and R. J. Hamilton eds, Rancidity in Foods, Elsevier Applied Science, London, Chapter 6). However, opposite findings are also documented. Wong *et al.* (1995) revealed that vitamin E is more effective than rosemary extract in a cooked beef homogenate. Additionally, rosemary extract is shown to be a synergist of vitamin E in stabilizing or retarding oxidation in sardine oil and fish muscle (Fang, X. and S. Wanda (1993), "Enhancing the antioxidant effect of α-tocopherol with rosemary extract in inhibiting catalyzed oxidation caused by Fe^{2+} and hemoprotein", Food Res Int 26: 405-411; Wanda, S. and X. Fang (1992), "The synergistic antioxidant effect of rosemary extract and α-tocopherol in sardine oil model system and frozen-crushed fish meat", J Food Process Preserv 16: 263-274).

As to the extraction of rosemary, many authors report that polar solvents yield extracts with higher antioxidant activities (Chang, S. S., B. Ostric-Matijasevic, C-L

Huang and OA-L Hsieh (1977), "Natural antioxidants from rosemary and sage", J Food Sci 42: 1102-1106). Chen *et al.* (1992) found that hexane extracts of rosemary contained a higher content of carnosic acid and carnosol than methanol extracts do. Carnosic acid and carnosol are the effective antioxidant molecules in rosemary. Carnosic acid and carnosol have been suggested to account for over 90% of the antioxidant activity of rosemary extracts (Aruoma, O. I, B. Halliwell, R. Aeschbach and J. Loligers (1992) "Antioxidant and pro-oxidant properties of active rosemary constituents: carnosol and carnosic acid", Xenobiotica 22: 257-268). Antioxidant molecules in general, and rosemary antioxidants specifically, are by nature labile molecules especially when exposed to heat and/or air. During the harvest, the drying, and the regular solvent extraction of rosemary some oxidation is likely to occur. Through a process of chemical reactions, carnosic acid, the naturally occurring antioxidant molecule in rosemary, is believed to be the precursor to carnosol and many other antioxidants found therein (Wenkert, E., A. Fuchs, J. D. McChesney (1965), "Chemical artifacts from the family labiate", J. Org. Chem. 30: 2931-2934). It can be demonstrated that the freshly cut leaves of rosemary do not contain carnosol (Aeschbach, R. and L. Philippossian (1993), "Carnosic acid obtention and uses", U.S. Patent No. 5,256,700). Carnosic acid is about 10 times more effective as an antioxidant than carnosol (Aruoma *et al.*, 1992) and it therefore is important for the high activity of a rosemary extract to minimize the damage to carnosic acid.

Summary of the Invention

The antioxidant activity of commercially available rosemary products were

compared with rosemary extracts prepared in the laboratory using various solvents for extraction. It was found that the antioxidant activity of commercial rosemary products was in the range of 2-5% when compared to mixed tocopherols. A methanol extract had 10% of the activity of mixed tocopherols. Methanol extraction, moreover, results in a dry powder that is difficult to dissolve into preferred carriers, such as edible oils. Accordingly, there was identified a goal to increase the specific activity of extracts of species of the family Labiate, including rosemary by optimizing the solvent extraction methodology and test alternate extraction technologies and to improve the handling characteristics of the extract.

The investigation into alternate extraction technology had two primary objectives. Firstly, to increase the specific activity of the rosemary extracts further for more efficient formulation into soybean oil or other carrier and, secondly, to identify technology allowing the removal of the essential oil fraction from the extracted material without oxidative destruction of the carnosic acid. One extraction technique investigated is based on tetrafluoroethane. Tetrafluoroethane has a boiling point of -27° C. The technology utilizes the vapor pressure of the solvent at room temperature and allows extraction under mild conditions, therefore minimizing the oxidative decomposition of carnosic acid during the extraction process. Tetrafluoroethane is substantially apolar and is preferably blended with acetone in the extractions of rosemary described here.

A process for the extraction of antioxidants from rosemary preferably meets several criteria. It should be economical and also lead to a liquid or oil extract that

can be formulated into a homogeneous, soybean oil-based final product that is largely free of odor. Methanol extracts the antioxidants from rosemary very effectively. However it leads to a dry powder extract and an inferior liquid final product after formulation into soybean oil. The extraction technology herein described is based on a solvent blend containing the solvent tetrafluoroethane (TFE) as major component. The optimum TFE-based solvent blend for the extraction of antioxidants from rosemary was identified and extraction parameters were defined. Among numerous solvent blends tested, an 80/15/5 blend of TFE/methanol/acetone, respectively, proved to be the most effective solvent resulting in a liquid extract with up to 35% of the tocopherol efficacy and an antioxidant yield of about 60% of the rosemary antioxidants.

The advantages of TFE show that it is non-flammable, has a low boiling point, is environmentally acceptable (very low toxicity), and is easily handled. It has been found that at ambient or sub-ambient temperatures, TFE leaves behind the majority of the waxes and other non-fragrant materials normally extracted with conventional solvents (Wilde P. F., 1994. Fragrance Extraction. European Patent No. 0616821A1). Another advantage with the use of TFE is that no distillation must be employed due to its low boiling point.

A purpose of the invention is to identify a solvent blend and extraction parameters for the extraction of antioxidants of rosemary while attaining a high specific activity and retaining high extraction yields.

Another purpose of the present invention is to provide a method for extracting antioxidants from rosemary that yields a liquid oily extract that is readily mixed with a

liquid product, such as soybean oil, for incorporation into animal feeds and human foods.

Brief Description of the Drawings

Fig. 1 is a chart of the antioxidant efficacy of a number of samples of rosemary extracted according to described methods.

Fig. 2 is a chart of the antioxidant efficacy of a number of samples of rosemary extracted according to described methods.

Fig. 3 is a chart of the antioxidant efficacy of a number of samples of rosemary extracted according to described methods.

Fig. 4 is a chart of the antioxidant efficacy of a number of samples of rosemary extracted according to described methods.

Fig. 5 is a chart of the antioxidant efficacy of a number of samples of rosemary extracted according to described methods.

Fig. 6 is a chart of the antioxidant efficacy of a number of samples of rosemary extracted according to described methods.

Fig. 7 is a chart of the antioxidant efficacy of a number of samples of rosemary extracted according to described methods.

Fig. 8 is a chart of the antioxidant efficacy of a number of samples of rosemary extracted according to described methods.

Fig. 9 is a schematic diagram of an extraction method of the present invention.

Fig. 10 is a schematic diagram of an extraction method of the present invention.

Fig. 11 is a schematic diagram of an extraction method of the present invention.

Fig. 12 is a schematic diagram of an extraction method of the present invention.

Detailed Description of Preferred Embodiments

The invention identifies methods of extracting rosemary with different TFE-based solvents and define preferred extraction conditions. A total of 17 different solvent blends, individually and combined, were used. While the specific organic solvents of acetone, butane, hexane, and methanol were used in the blends presented in the data, other organic solvents could be employed within the scope of this invention, including but not limited to acetone, butane, ethanol, ethylene chloride, hexane, isopropanol, methanol, methylene chloride, and propylene glycol. Data presents the results of the analysis of extracts of rosemary produced from the Arp variety in terms of extraction yield (%) and percent efficacy when compared to 100% mixed tocopherols at equal applications of 500 ppm tested in chicken fat, and rosemary extract/tocopherols equivalency.

All samples were tested in untreated chicken fat at a treatment level of 500 ppm. These samples were then placed into an oxygen bomb pressurized to 50 psi with oxygen, placed in silicon oil at 100° C and allowed to oxidize. All samples were compared against the induction time of fat treated with 250 ppm 100% mixed tocopherols at a calculated equal concentration level of 500 ppm.

In the data tables, the sample number, the solvent used, percent yield, percent efficacy of tocopherols, and equivalency of rosemary extract to grams of tocopherols are reported. The percent yield was calculated by dividing the yield of rosemary extract by the initial mass of rosemary and multiplication by 100%. The percent efficacy to

tocopherols was calculated as follows:

$$\frac{(IT_{sample}(500\ ppm)\text{-}IT_{control})}{(2\ X\ (IT_{tocopherols250ppm}\text{-}IT_{control}))}\ X\ 100\%$$

where "IT" is the induction time.

Tocopherol equivalent units (g) were calculated using the assumptions that 1.0 kg rosemary was extracted according to the individual methods, and the percent yield and percent efficacy are equivalent from the small scale to the large scale extraction process:

1000 g rosemary X (% yield/100%) X (% efficacy/100%) = tocopherol equivalent (g).

The poultry fat, used as a test matrix, was supplied from Tyson. The various rosemary accessions were obtained from the Chart Co., Papa Geno's Herb Garden, and the North Carolina Botanical Garden. All solvents were purchased from Fisher Scientific Co. The apparatus that the TFE/organic experiments were conducted in was purchased from the Advanced Phytonics facility in Cowfold Grange, U.K. All rosemary leaves used in these experiments were from the Arp variety unless otherwise noted.

METHOD 1

Effect of solvent blends on efficacy

For samples 1-17 and 26, 2.0 g of dried, ground rosemary leaves were introduced into a closed glass vial extractor. The sample was then extracted with 20 g tetrafluoroethane (TFE) or a TFE/solvent mix for two hours. At this time the filtrate was quantitatively transferred into a glass collection vial. The rosemary was then washed with 10.0 g of the extraction solution for five minutes. This liquid portion was added to the first filtrate collected. The rosemary was washed a second time with 10.0 g of the

extracting solution and this was also added to the collection vial. After all of the filtrate solutions had been combined, the pressure in the vial was slowly released. After all of the TFE had evaporated, the other organic solution was removed under a stream of nitrogen gas under moderate heating. The extraction process is illustrated diagrammatically in Fig. 9.

The purpose of this series of experiments (Figure 1, samples 1-7) was to test the performance of various TFE/acetone blends for the extraction of antioxidants from rosemary. When used alone, TFE results in poor yield with low efficacy. Acetone was added in small amounts to the TFE, initially at a concentration of 5%. The efficacy of the extracts was increased dramatically, up to six-fold, when sample number 2 (95% TFE/5% acetone) was compared to the efficacy of the sample number 1 (100% TFE). As the concentration of the acetone was increased, yields increased steadily while the specific efficacy remained essentially the same after an initial steep increase. It appears that with increasing concentrations of acetone, the blend equally well extracts antioxidant components as well as non-antioxidant components. The yield data are presented in Table 1 and the antioxidant efficacy is illustrated in Fig. 1.

TABLE 1

No.	Solvent	% Yield	% Efficacy to Tocopherols	Tocopherol Equivalent Units (g)
1	100% TFE	0.95	5.84	0.555
2	95% TFE/5% acetone	3.27	35.71	11.7
3	90% TFE/10% acetone	5.06	37.01	18.7
4	85% TFE/15% acetone	6.50	35.71	23.21
5	80% TFE/20% acetone	6.11	34.41	21.0
6	75% TFE/25% acetone	6.54	34.41	22.5
7	70% TFE/30% acetone	7.49	27.92	20.9

The purpose of the next set of experiments (Figure 2, samples 1, 8-13) was to test the effect of varying the concentration of hexane when mixed with TFE. Generally, the effect of hexane added to TFE had a less pronounced effect on the performance when compared to the acetone results. However, as was observed with the acetone, hexane was also able to improve the efficacy of the extracts by five-fold when compared to sample number 1 (100% TFE). The yield data are presented in Table 2 and the antioxidant efficacy is illustrated in Fig. 2.

TABLE 2

No.	Solvent	% Yield	% Efficacy to Tocopherols	Tocopherol Equivalent Units (g)
1	100% TFE	0.95	5.84	0.555
8	95% TFE/5% hexane	1.90	24.02	4.6
9	90% TFE/10% hexane	2.79	24.02	6.7
10	85% TFE/15% hexane	4.85	24.02	11.6
11	80% TFE/20% hexane	5.69	24.02	13.7
12	75% TFE/25% hexane	5.46	26.62	14.53
13	70% TFE/30% hexane	6.40	26.62	17.0

Figures 3 and 4 (samples 2-13) compare the two different groups of solvent systems in terms of yields and specific activity. A steady increase in extraction yields can be noted as the TFE is replaced by the two solvents hexane or acetone. As to the specific activity, a rapid increase followed by a long plateau is observed. On average the TFE/acetone extracts outperformed the TFE/hexane extracts by about 10% in terms of specific activity. However, at a concentration of 30% for both solvents, the extracts were approximately equal in efficacy.

Additional solvents and solvent mixes were tested in an attempt to increase the efficacy and the total antioxidant yield extracted from the rosemary. Table 4 and Figure 5 (samples 1 and 14-17) display the results of these experiments. When a 90% TFE/10% butane blend was evaluated a three-fold increase in efficacy over sample number 1 (100% TFE) was observed. The TFE/butane extract was equal to a methanol extract. Next, several three-solvent blends were tested. The two solvents mixed with TFE were methanol and acetone, varying in concentration from 5 to 15 percent (see Table 4). Using a solvent mix of 80% TFE/15% MeOH/5% acetone, the extract obtained displayed the highest total yield with a specific efficacy of 29.22% of that of tocopherol and an extraction yield of 10.05%. Methanol in combination with acetone seems to augment extraction yields while maintaining high specific efficacy. The yield data are presented in Table 3 and the antioxidant efficacy is illustrated in Fig. 5.

TABLE 3

No.	Solvent	% Yield	% Efficacy to Tocopherols	Tocopherol Equivalent Units (g)
1	100% TFE	0.95	5.84	0.555
14	90% TFE/10% butane	NA	20.12	----
15	80% TFE/5% MeOH/15% acetone	7.85	30.52	23.9
16	80% TFE/10% MeOH/10% acetone	6.34	34.42	21.8
17	80% TFE/15% MeOH/5% acetone	10.05	29.22	29.4

METHOD 2

Effect of Multiple Extractions on Efficacy and Yield

For sample 18, 2.0 g of dried ground rosemary leaves were introduced into the glass-extracting vial. The sample was then extracted with 20.0 g of 85% TFE/15% acetone for two hours. This was repeated once more. At this time 40.0 g of the solvent mix was added to the extraction vial containing the rosemary. This was allowed to stand for 20 hours. The solvent was then removed and added to the previous two. The TFE was then allowed to evaporate off and the acetone was removed under a stream of nitrogen gas with slight heat. The process is illustrated diagrammatically in Fig. 10.

The possibility of attaining higher yields with repeated extractions while retaining the high efficacy of the extracts was explored. Figure 6 represents the antioxidant activity of sample 18. Sample 18 was produced from the repeated extraction of rosemary over a 24-hour period using 85% TFE/15% acetone. No appreciable increase in the yield or decrease in efficacy was observed when compared to a single extraction. Table 4 presents the yield data.

TABLE 4

No.	Solvent	% Yield	% Efficacy to Tocopherols	Tocopherol Equivalent Units (g)
18	85% TFE/15% acetone	6.70	33.12	22.2

METHOD 3

Effect of Extracting a Methanol Extract of Rosemary with a TFE Blend

Sample 19 was prepared by taking 100.0 g of Arp rosemary leaves and extracting it with 600 ml of methanol for 48 hours. This was then filtered and the methanol was evaporated via vacuum rotary evaporator at 40° C. Samples 20 and 22 were prepared by taking 1.0 g of sample 19 and putting it into a glass-extracting vial. For sample 20, 10 g of 85% TFE/15% acetone was added to the 1.0 g of sample 19. This solution was allowed to extract the 1.0 g sample for two hours. This solution was then filtered away from the sample. This was repeated once more. Both solutions were then combined and the TFE was allowed to boil off and the acetone was removed under a stream of nitrogen gas with slight heat. For sample 22, the same method was followed to prepare sample 20, however, instead of using 85% TFE/15% acetone as the extracting solvent, 70% TFE/30% hexane was used. The material (bagasse) that was left over from the process of preparing samples 20 and 22 was labeled 21 and 23, respectively. This process is illustrated schematically in Fig. 11.

The possibility of utilizing the TFE based extraction process to further deodorize and purify a methanol extract of rosemary was explored (see Figure 7). Methanol extracts

possess close to 100% of the antioxidants from rosemary. With this in mind, TFE mixed with an organic solvent (acetone or hexane) may separate out or extract a larger majority of the antioxidants from a methanol extract over dried, ground rosemary leaves. The test was performed with both, acetone and hexane. Initial tests indicated that the TFE blend solvent extracts were approximately equal to the methanol extracts of dried, ground rosemary. The non-extracted portion, the bagasse, left over from the TFE based extraction (samples 21 and 23), retained a large amount of the antioxidant activity which had 13.64% and 12.34%, respectively, of the tocopherol activity. This residual efficacy indicated the lack of ability of the TFE/organic solvent mix to extract 100% of the antioxidants from a methanol extract of rosemary. However, there are still many solvents and factors to be tested that will inevitably increase the efficacy as well as the extraction yield. Table 5 presents the yield data and Fig. 7 displays the antioxidant efficacy.

TABLE 5

No.	Solvent	% Yield	% Efficacy to Tocopherols	Tocopherol Equivalent Units (g)
19	100% methanol	27.66	20.13	36.0
20	85% TFE/15% acetone	3.91	38.31	15.0
21	Residue	NA	13.64	----
22	70% TFE/30% hexane	6.06	33.12	20.1
23	Residue	NA	12.34	----

METHOD 4

Extraction of Rosemary with 90%TFE/10% acetone

followed by extraction of the bagasse with methanol

Sample 24 was prepared by taking 15.0 g of ground rosemary and placing it into a 250 ml-extracting vial. To this was added 100.0 g of a 90% TFE/10% acetone solvent mixture. This was allowed to stand for two hours and then the solvent was filtered away. The TFE was allowed to boil away and the acetone was removed under a stream of nitrogen gas with slight heat. The remaining bagasse was used to create sample 25. Sample 25 was prepared in the following way. Firstly, the remaining unextracted rosemary left over from the preparation of sample 24 was put into a 250 ml flask and 60 ml of methanol was added. This was allowed to extract for 48 hours. At this point, the solution was filtered and the methanol was removed via vacuum rotary evaporator at 40° C. This process is illustrated diagrammatically in Fig. 12

Whether any residual antioxidants are left after an extraction with a TFE blend was investigated (see Figure 8). A sample of rosemary was extracted with a 90% TFE/10% acetone (sample 24) mix and the residual rosemary material was extracted with methanol (sample 25). The results indicated that a blend of TFE/10% acetone extracted approximately 30% of the antioxidants in rosemary. It appears that the presence of methanol in the solvent blend for the extraction of rosemary is critical for economical yields. The yield data are presented in Table 6 and the antioxidant efficacy displayed in Fig. 8.

TABLE 6

No.	Solvent	% Yield	% Efficacy to Tocopherols	Tocopherol Equivalent Units (g)
24	90% TFE/10% acetone	4.00	31.82	12.7
25	100% methanol	23.7	12.34	29.24

Although the invention has been described with respect to a preferred embodiment thereof, it is to be also understood that it is not to be so limited since changes and modifications can be made therein which are within the full intended scope of this invention as defined by the appended claims.

We claim:

1. A process for extracting a natural organic component from organic material, comprising the steps of:

(a) contacting the organic material in a vessel with a blend of tetrafluoroethane and at least one organic solvent to dissolve the natural organic component in the solvent blend;

(b) removing the remaining organic material from the solution of the natural organic component and the solvent blend; and

(c) removing the solvent blend to isolate a liquid, oily product containing the natural organic component.

2. The process of claim 1, wherein the organic solvent is selected from the group including acetone, butane, ethanol, ethylene chloride, hexane, isopropanol, methanol, methylene chloride, and propylene glycol.

3. The process of claim 1, wherein the solvent blend comprises from between about 60% to about 95% tetrafluoroethane.

4. The process of claim 3, wherein the solvent blend comprises tetrafluoroethane and at least two organic solvents.

5. The process of claim 4, wherein the organic solvents are selected from the group including acetone, butane, hexane, and methanol.

6. The process of claim 5, wherein the solvent blend comprises between about 70% and about 85% tetrafluoroethane, between about 1% and about 25% acetone, and between about 1% and about 25% methanol.

7. The process of claim 3, wherein the solvent blend comprises between about 70% and about 95% tetrafluoroethane and the organic solvent is acetone.

8. The process of claim 3, wherein the solvent blend comprises between about 70% and about 90% tetrafluoroethane and the organic solvent is methanol.

9. The process of claim 3, wherein the solvent blend comprises between about 70% and about 90% tetrafluoroethane and the organic solvent is hexane.

10. The process of claim 1, wherein the natural organic component includes an antioxidant.

11. The process of claim 10, wherein the natural organic component includes organic molecules having polarity comparable to antioxidants.

12. The process of claim 1, wherein the step of removing the solvent blend includes allowing the tetrafluoroethane to be reclaimed.

13. A process for extracting molecules having polarity comparable to antioxidants from botanical material, comprising the steps of:

(a) contacting the botanical material in a vessel with a blend of tetrafluoroethane and at least one organic solvent to dissolve the molecules in the solvent blend;

(b) removing the remaining botanical material from the solution of the molecules and the solvent blend; and

(c) removing the solvent blend to isolate a liquid, oily product containing the molecules.

14. A process for extracting a natural organic component from botanical material, comprising the steps of:

(a) contacting the botanical material in a vessel with a blend of tetrafluoroethane and at least one organic solvent to dissolve the natural organic component in the solvent blend;

(b) removing the remaining botanical material from the solution of the natural organic component and the solvent blend; and

(c) removing the solvent blend to isolate a liquid, oily product containing the natural organic component which has antioxidant activity that is improved over a natural component extracted in the absence of the organic solvent.

15. The process of claim 14, wherein the liquid, oily product is readily soluble in an edible oil.

16. The process of claim 14, wherein the botanical material is at least one species selected from the family Labiatae.

17. The process of claim 14, wherein the botanical material is *Rosemarinus officinalis*.

18. A preservative for foods and animal feedstuffs, comprising a mixture of the liquid, oily product obtained from the process of claim 14 and an edible oil.

19. An orally administered antioxidant for humans and animals, comprising a mixture of the liquid, oily product obtained from the process of claim 14 and an edible carrier.

Abstract

An increase in specific antioxidant activity of extracts from rosemary (*Rosemarinus officinalis*) is obtained by the use of a blend of tetrafluoroethane and acetone in the extraction process. A blend of tetrafluoroethane, acetone and methanol improves total yield. A tetrafluoroethane and acetone blend has higher efficacy but comparatively lower yields. The methods yield a liquid and oily extract that is readily mixed with a liquid product such as soybean oil for addition to animal feeds and human food.

FIGURE 1

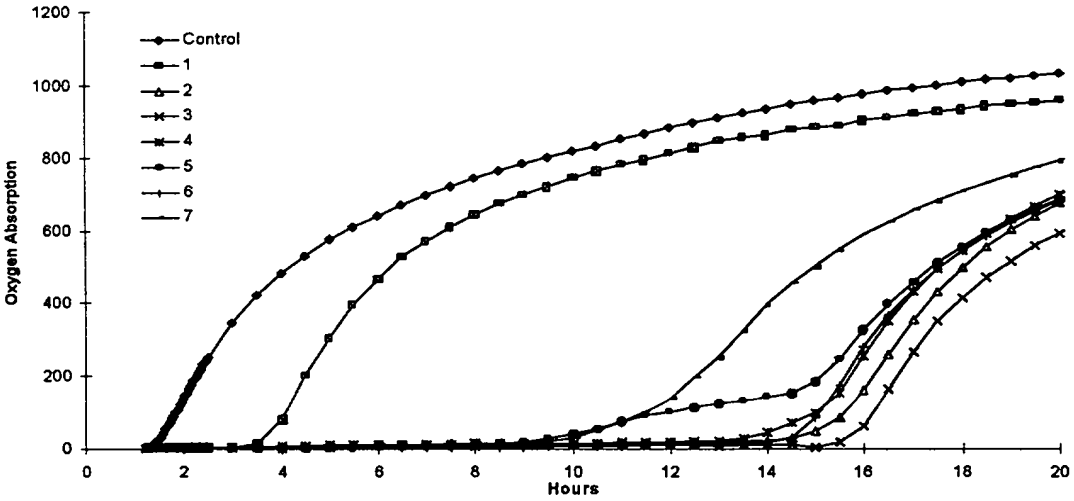


FIGURE 2

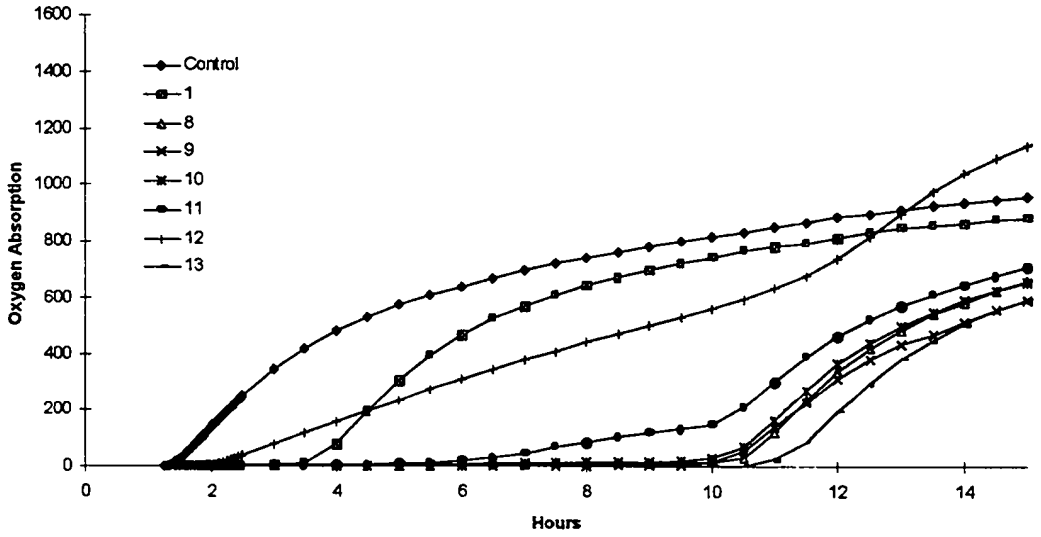


FIGURE 3

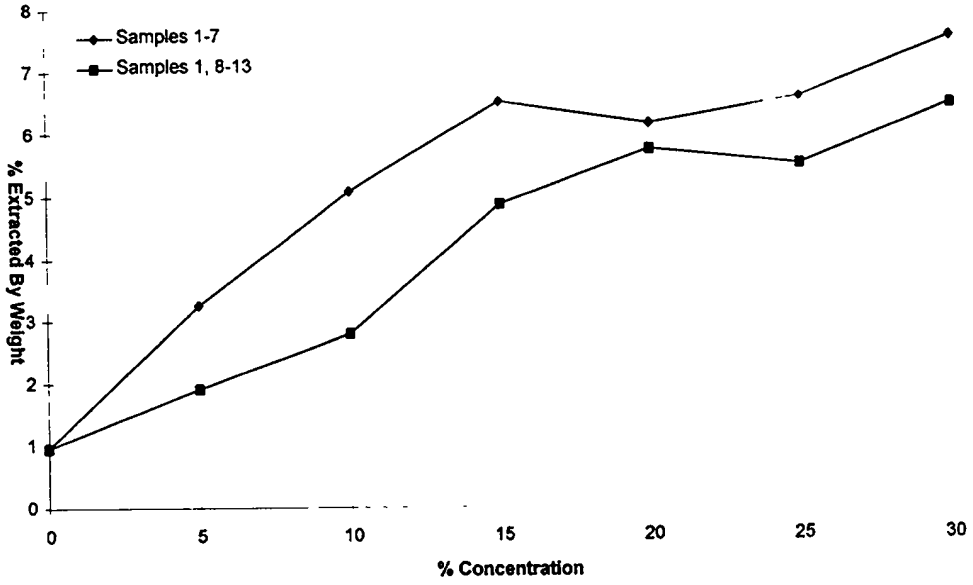


FIGURE 4

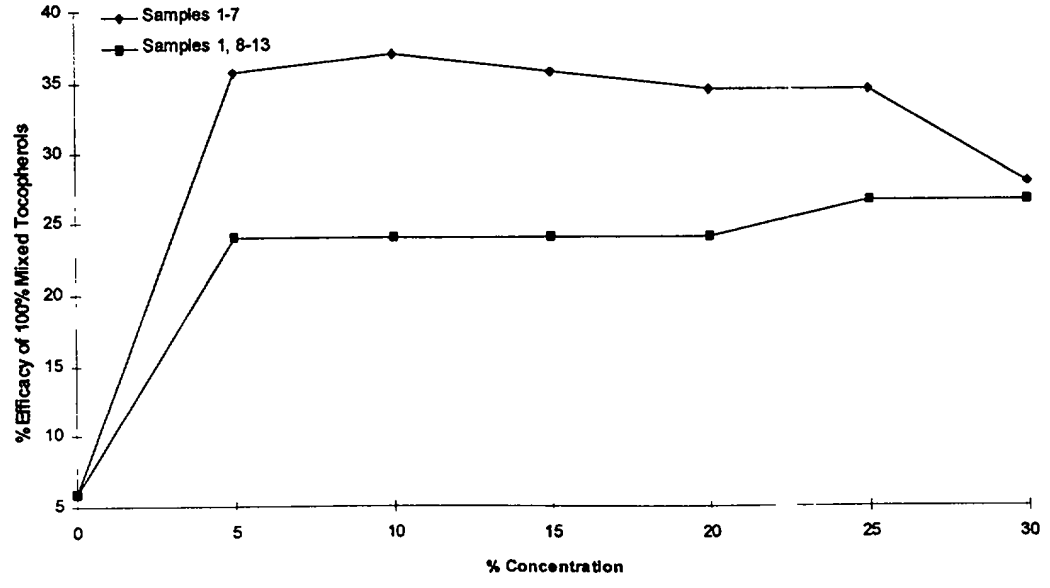


FIGURE 5

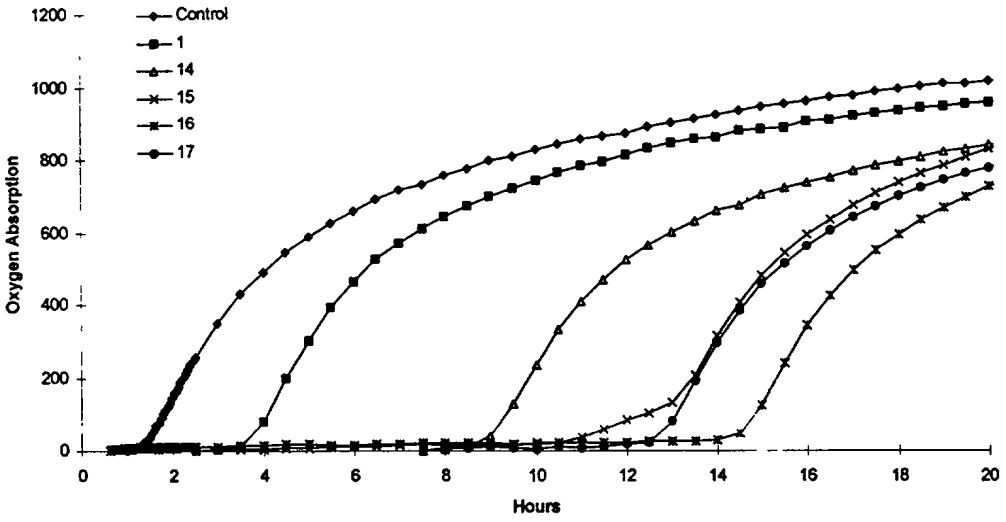


FIGURE 6

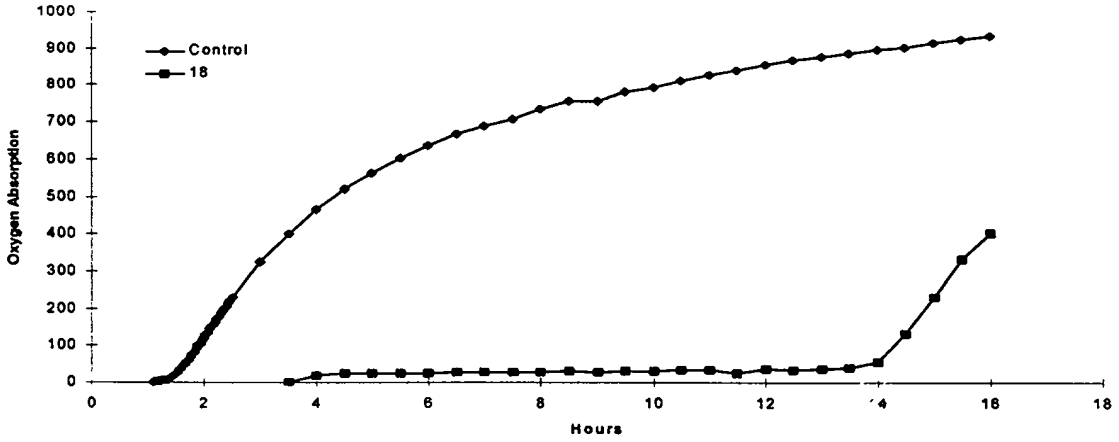


FIGURE 7

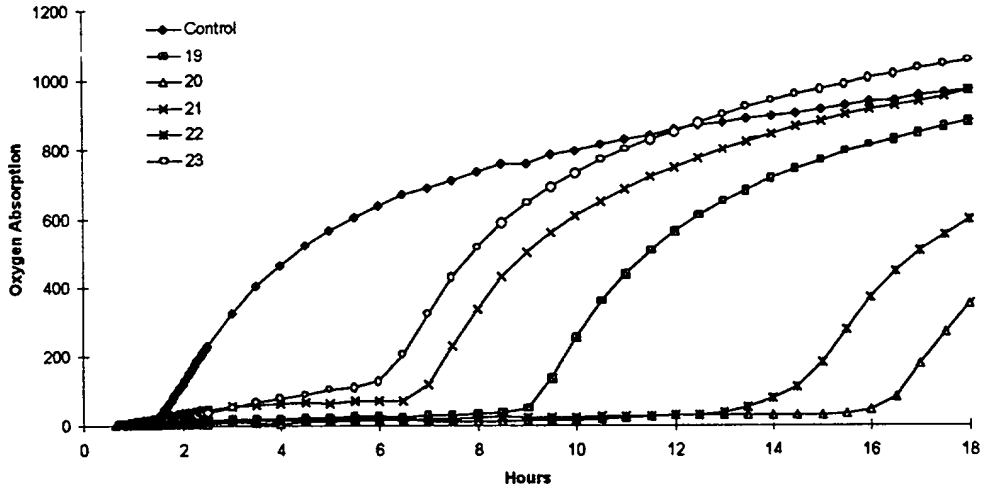


FIGURE 8

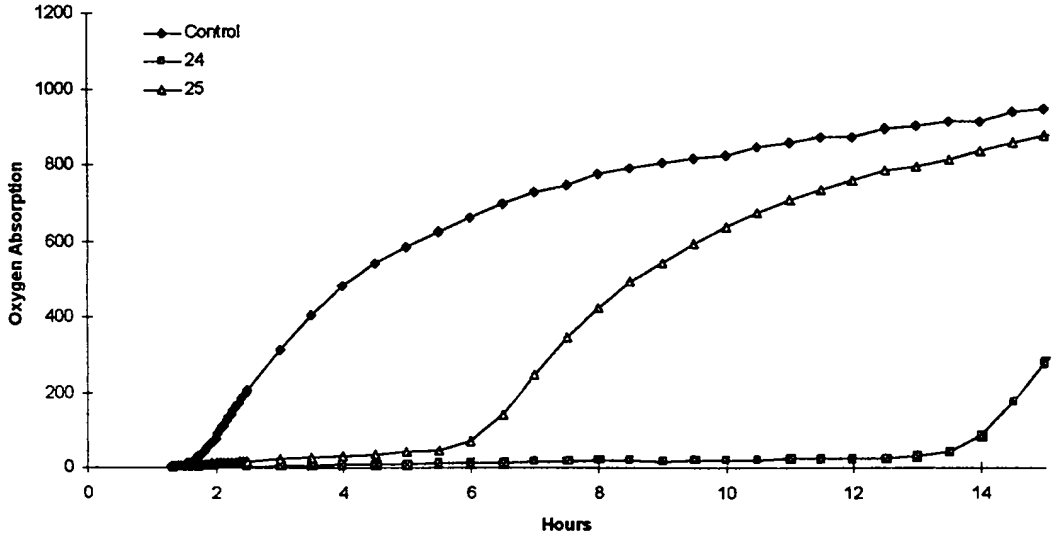


FIGURE 9

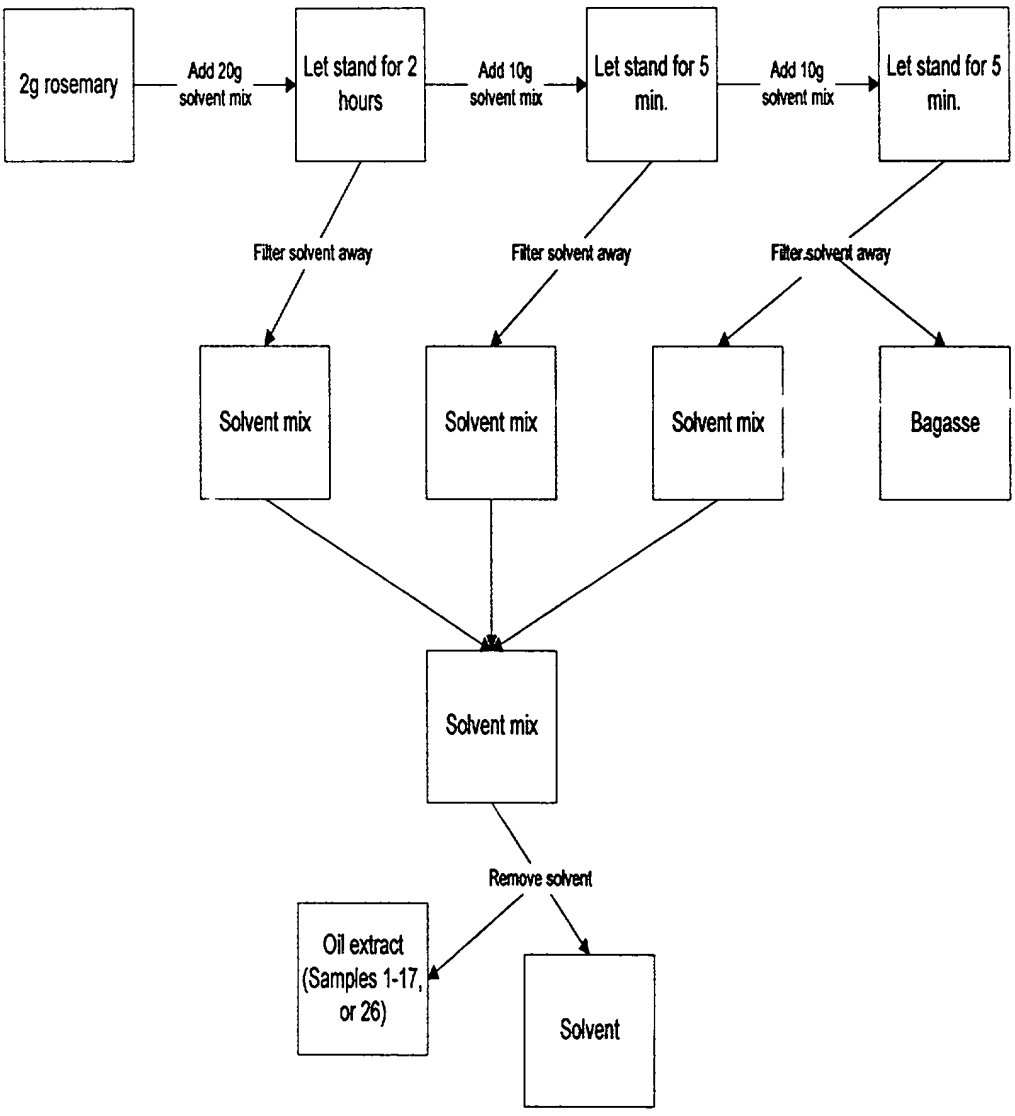

2g rosemary
Add 20g solvent mix
Let stand for 2 hours
Add 10g solvent mix
Let stand for 5 min.
Add 10g solvent mix
Let stand for 5 min.
Filter solvent away
Filter solvent away
Filter solvent away
Solvent mix
Solvent mix
Solvent mix
Bagasse
Solvent mix
Remove solvent
Oil extract (Samples 1-17, or 26)
Solvent

FIGURE 10

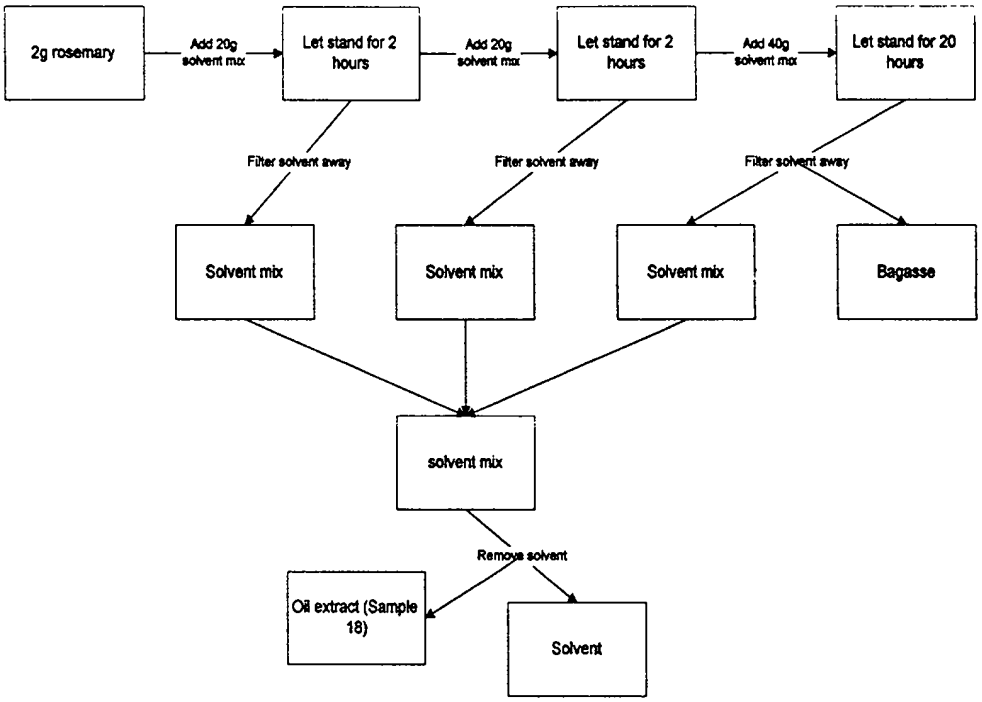

2g rosemary
Add 20g solvent mix
Let stand for 2 hours
Add 20g solvent mix
Let stand for 2 hours
Add 40g solvent mix
Let stand for 20 hours
Filter solvent away
Filter solvent away
Filter solvent away
Solvent mix
Solvent mix
Solvent mix
Bagasse
solvent mix
Remove solvent
Oil extract (Sample 18)
Solvent

FIGURE 11

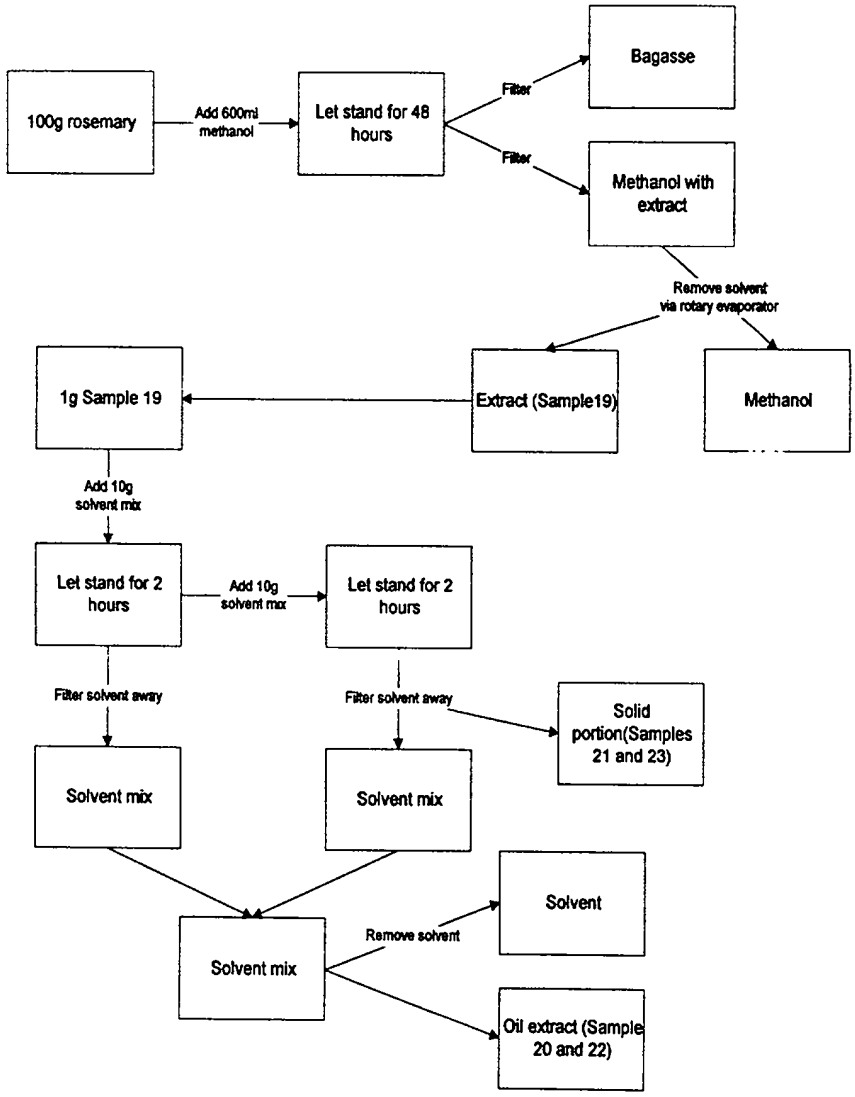
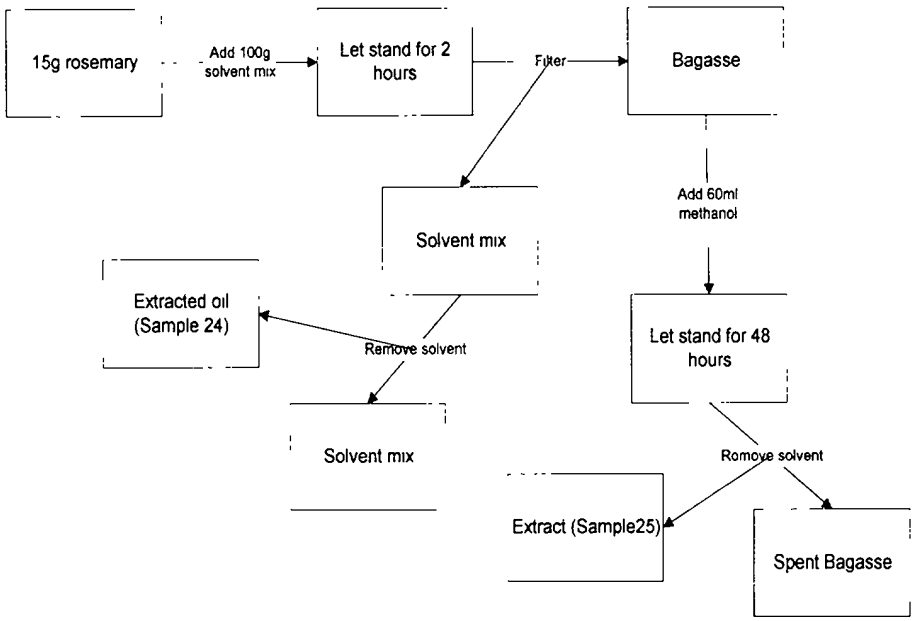

100g rosemary
Add 600ml methanol
Let stand for 48 hours
Filter
Bagasse
Filter
Methanol with extract
Remove solvent via rotary evaporator
1g Sample 19
Extract (Sample19)
Methanol
Add 10g solvent mix
Let stand for 2 hours
Add 10g solvent mix
Let stand for 2 hours
Filter solvent away
Filter solvent away
Solid portion(Samples 21 and 23)
Solvent mix
Solvent mix
Solvent
Remove solvent
Solvent mix
Oil extract (Sample 20 and 22)

FIGURE 12


15g rosemary
Add 100g solvent mix
Let stand for 2 hours
Filter
Bagasse
Add 60ml methanol
Solvent mix
Extracted oil (Sample 24)
Remove solvent
Let stand for 48 hours
Solvent mix
Remove solvent
Extract (Sample25)
Spent Bagasse

COMBINED DECLARATION AND POWER OF ATTORNEY

As a below-named inventor, I hereby declare that:

My residence, post office address, and citizenship are as stated below next to my name.

I believe that I am an original inventor of the subject matter which is claimed and for which a patent is sought on the invention entitled METHOD OF EXTRACTING ANTIOXIDANTS FROM LAMIACEAE SPECIES AND THE EXTRACT PRODUCTS THEREOF, the specification of which

(check one) [X] is attached hereto.

[ ] was filed on _____ _____, 19_____
as Application Serial No. _____
and was amended on _____.
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
(Number)	(Country)	(Day/Month/Year Filed)	[ ] Yes	[ ] No

POWER OF ATTORNEY

As a named inventor, I hereby appoint the following attorney(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith:

Kent A. Herink Reg. No. 31,025

Send correspondence and direct all telephone calls to:

Kent A. Herink
DAVIS, BROWN, KOEHN, SHORS & ROBERTS, P.C.
The Financial Center
666 Walnut Street, Suite 2500
Des Moines, Iowa 50309-3993
(515) 288-2500 (phone)
(515) 243-0654 (fax)

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of first inventor: James Haworth

Inventor's signature: James Haworth

Date: 5-15-98

Residence: Des Moines, Iowa

Citizenship: U.S.A.

Post Office Address: 2100 Maury Street, Box 70, Des Moines, Iowa 50301

Full name of second inventor: Friedhelm Brinkhaus

Inventor's signature: Friedhelm Brinkhaus

Date: 5-15-98

Residence: Des Moines, Iowa

Citizenship: U.S.A.

Post Office Address: 2100 Maury Street, Box 70, Des Moines, Iowa 50301

Full name of third inventor: John Greaves

Inventor's signature: ______________________

Date: May 14th 1998

Residence: Des Moines, Iowa

Citizenship: U.S.A.

Post Office Address: 2100 Maury Street, Box 70, Des Moines, Iowa 50301

Applicant or Patentee: James Haworth, Friedhelm Brinkhaus and John Greaves Attorney's Docket No. 4532670/19300
Serial or Patent No.:
Filed or Issued:
For: METHOD OF EXTRACTING ANITOXIDANTS FROM LAMIACEAE SPECIES AND THE EXTRACT PRODUCTS THEREOF

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 C.F.R. 1.9(f) and 1.27(b) - INDEPENDENT INVENTOR

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 C.F.R. 1.9(c) for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled **METHOD OF EXTRACTING ANTIOXIDANTS FROM LAMIACEAE SPECIES AND THE EXTRACT PRODUCTS THEREOF** described in

- ☒ the specification filed herewith
- ☐ application serial no. , filed
- ☐ patent no. , issued

I have not assigned, granted, conveyed or licensed and am under no obligation under contract or law to assign, grant, convey or license, any rights in the invention to any person who could not be classified as an independent inventor under 37 C.F.R. 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 C.F.R. 1.9(d) or a nonprofit organization under 37 C.F.R. 1.9(e).

Each person, concern or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

- ☐ no such person, concern or organization
- ☒ persons, concerns or organizations listed below*

*NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities. (37 C.F.R. 1.27)

FULL NAME: Kemin Industries, Inc.
ADDRESS: 2100 Maury Street, Box 70, Des Moines, Iowa 50301
☐ INDIVIDUAL ☒ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

FULL NAME:
ADDRESS:
☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

FULL NAME:
ADDRESS:
☐ INDIVIDUAL ☐ SMALL BUSINESS CONCERN ☐ NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 C.F.R. 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

James Haworth	Friedhelm Brinkhaus	John Greaves
Name Of Inventor	Name Of Inventor	Name Of Inventor
James Haworth	F. Brinkhaus	John Greaves
Signature of Inventor	Signature of Inventor	Signature of Inventor
5-15-98	5-15-98	5-18-98
Date	Date	Date

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Docket No. 4532670/19300

Applicant or Patentee: Kemin Industries, Inc.
Serial No. or Patent No:
Filed or Issued:
For: METHOD OF EXTRACTING ANTIOXIDANTS FROM
LAMIACEAE SPECIES AND THE EXTRACT PRODUCTS THEREOF

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS (37 CFR 1.9(f) AND 1.27(c)) - SMALL BUSINESS CONCERN

I hereby declare that I am

[ ] the owner of the small business concern identified below:
[X] an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN: Kemin Industries, Inc.
ADDRESS OF CONCERN: 2100 Maury Street, Box 70, Des Moines, Iowa 50301

I hereby declare that the above-identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention, entitled METHOD OF EXTRACTING ANTIOXIDANTS FROM LAMIACEAE SPECIES AND THE EXTRACT PRODUCTS THEREOF by inventor(s) John Greaves, Friedhelm Brinkhaus and James Haworth, described in

[X] the specification filed herewith.

[ ] application Serial No. , filed .
[ ] Patent No. , issued .

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights in the invention is listed below* and no rights to the invention are held by any person, other than the inventor, who would not qualify as an independent inventor under 37 CFR 1.9(c) if that person made the invention, or by any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

**NOTE:* *Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities (37 CFR 1.27)*

FULL NAME: Kemin Industries, Inc.
ADDRESS: 2100 Maury Street, Box 70, Des Moines, Iowa 50301
[ ] INDIVIDUAL [X] SMALL BUSINESS CONCERN [ ] NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of payment, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of payment, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate. (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME AND TITLE OF PERSON SIGNING: Christopher E. Nelson, President
ADDRESS OF PERSON SIGNING: 2100 Maury Street, Box 70, Des Moines, Iowa 50801
SIGNATURE Christopher E. Nelson DATE 5/14/98